U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

An Overview of AMO Strategic Analysis

Joe Cresko - Advanced Manufacturing Office, DOE

AMO Program Peer Review

June 11, 2019

Arlington, VA

ANL – Diane Graziano, Matt Riddle, John Murphy, Sarang Supekar, Nwike Iloeje

LBNL – Arman Shehabi, William Morrow, Sarah Smith, Prakash Rao

NREL – Alberta Carpenter, Rebecca Hanes, Samantha Reese, Scott Nicholson, James McCall, Debbie Sandor

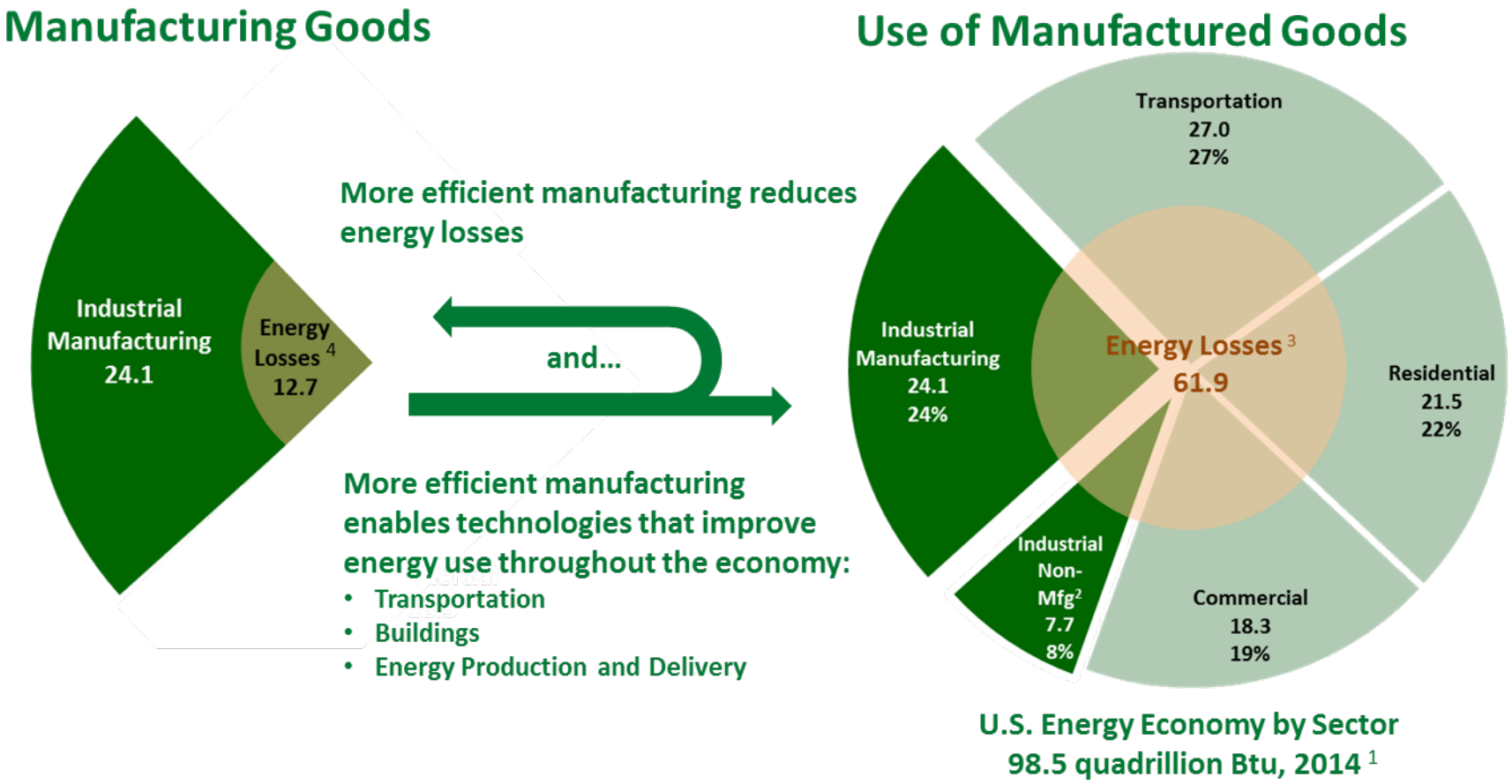
ORNL – Sujit Das, Sachin Nimbalkar, Kristina Armstrong, Kiran Thirumaran, Kanchan Upadhyay

Energetics – Sabine Brueske, Caroline Dollinger

What is the opportunity space for advanced manufacturing?

Success Indicators:

- Improve the productivity and energy efficiency of U.S. manufacturing.
- Reduce life cycle energy and resource impacts of manufactured goods.



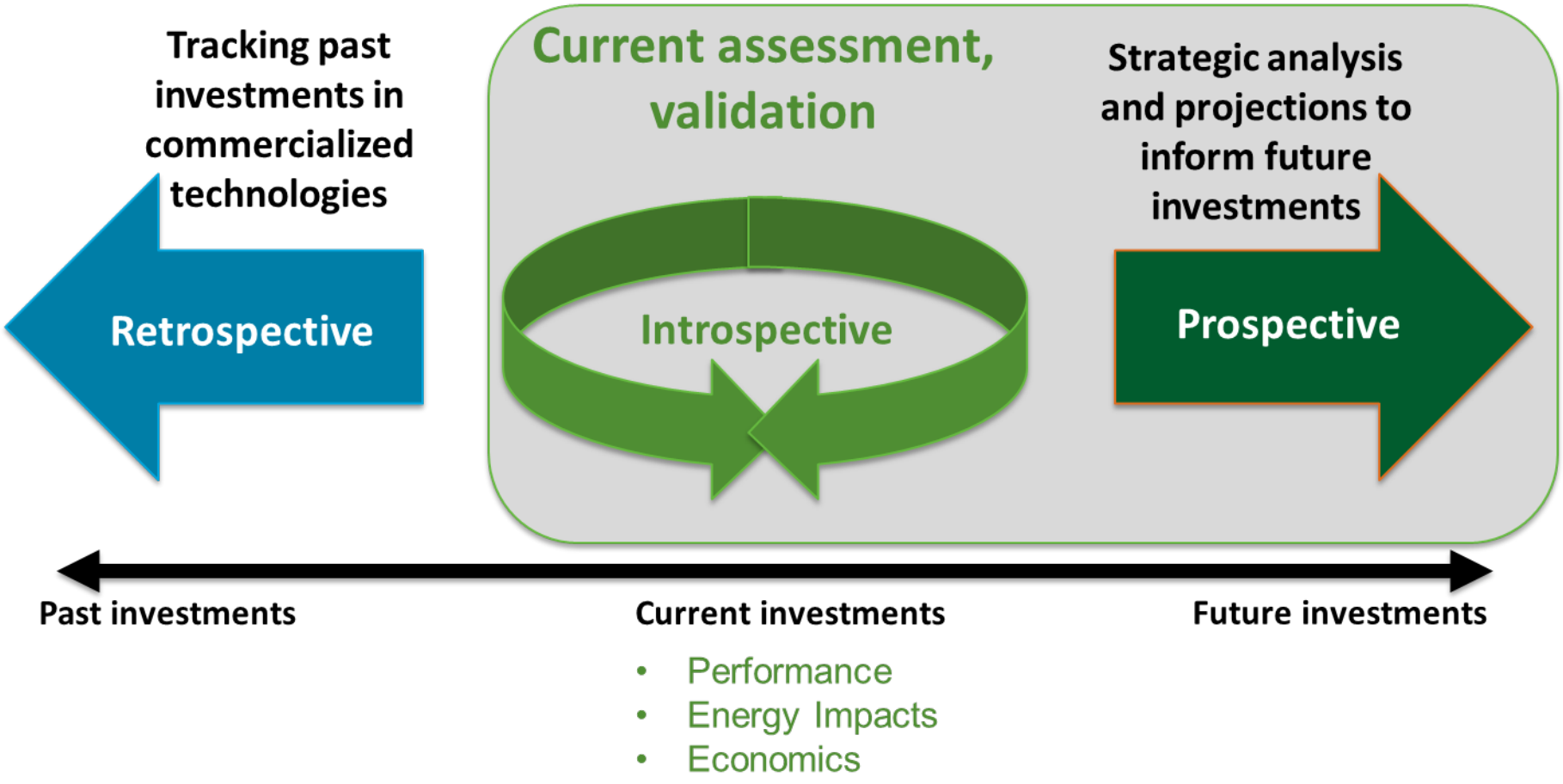
[1] Energy consumption by sector from EIA Monthly Energy Review, 2018

[2] Industrial non-manufacturing includes agriculture, mining, and construction

[3] US economy energy losses determined from LLNL Energy Flow Chart 2014 (Rejected Energy), adjusted for manufacturing losses

[4] Manufacturing energy losses determined from DOE AMO Footprint Diagrams (2014 data)

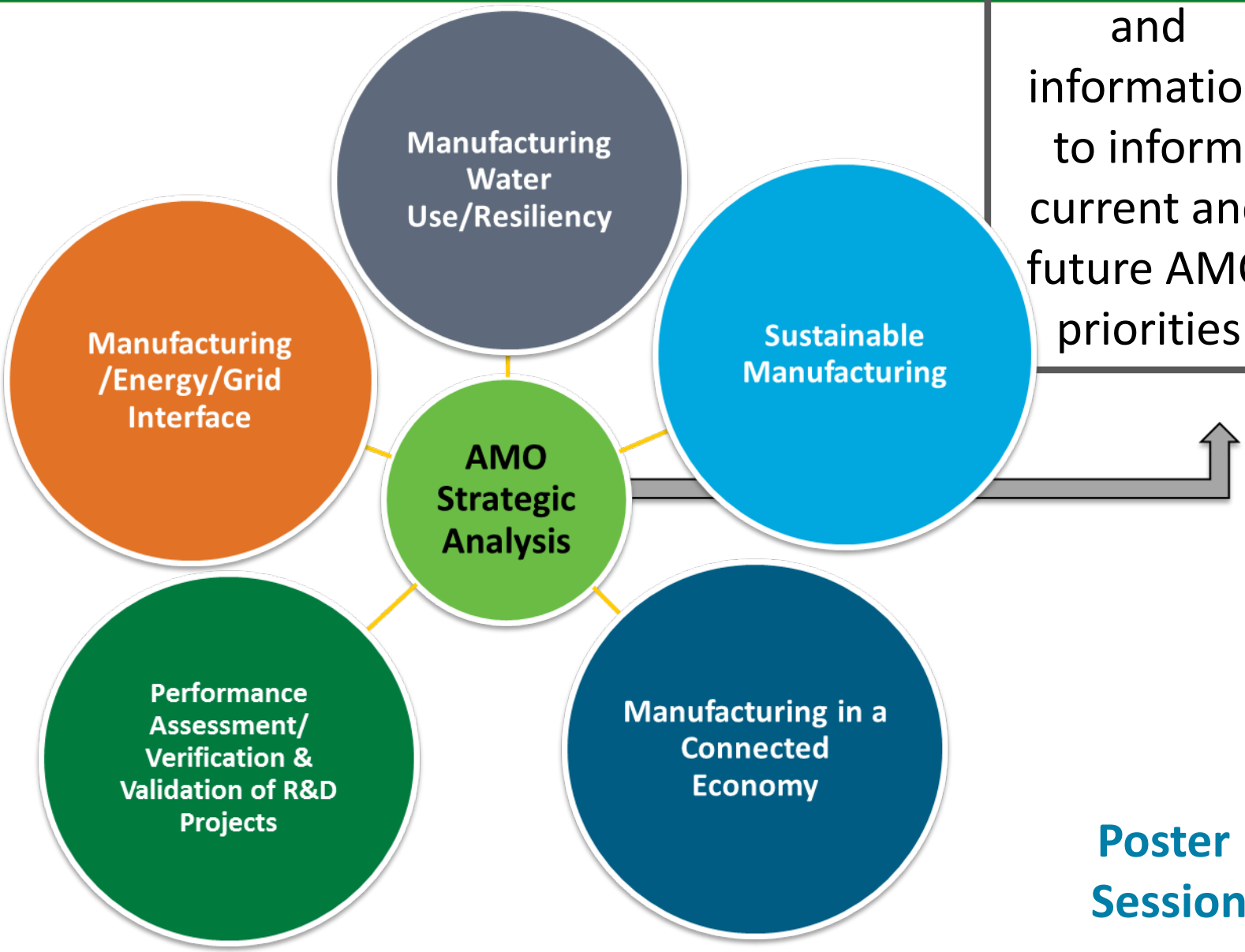
Context – AMO Analysis Framework



Cycle of prospective, introspective and retrospective helps AMO gain a sense of investment impacts across time

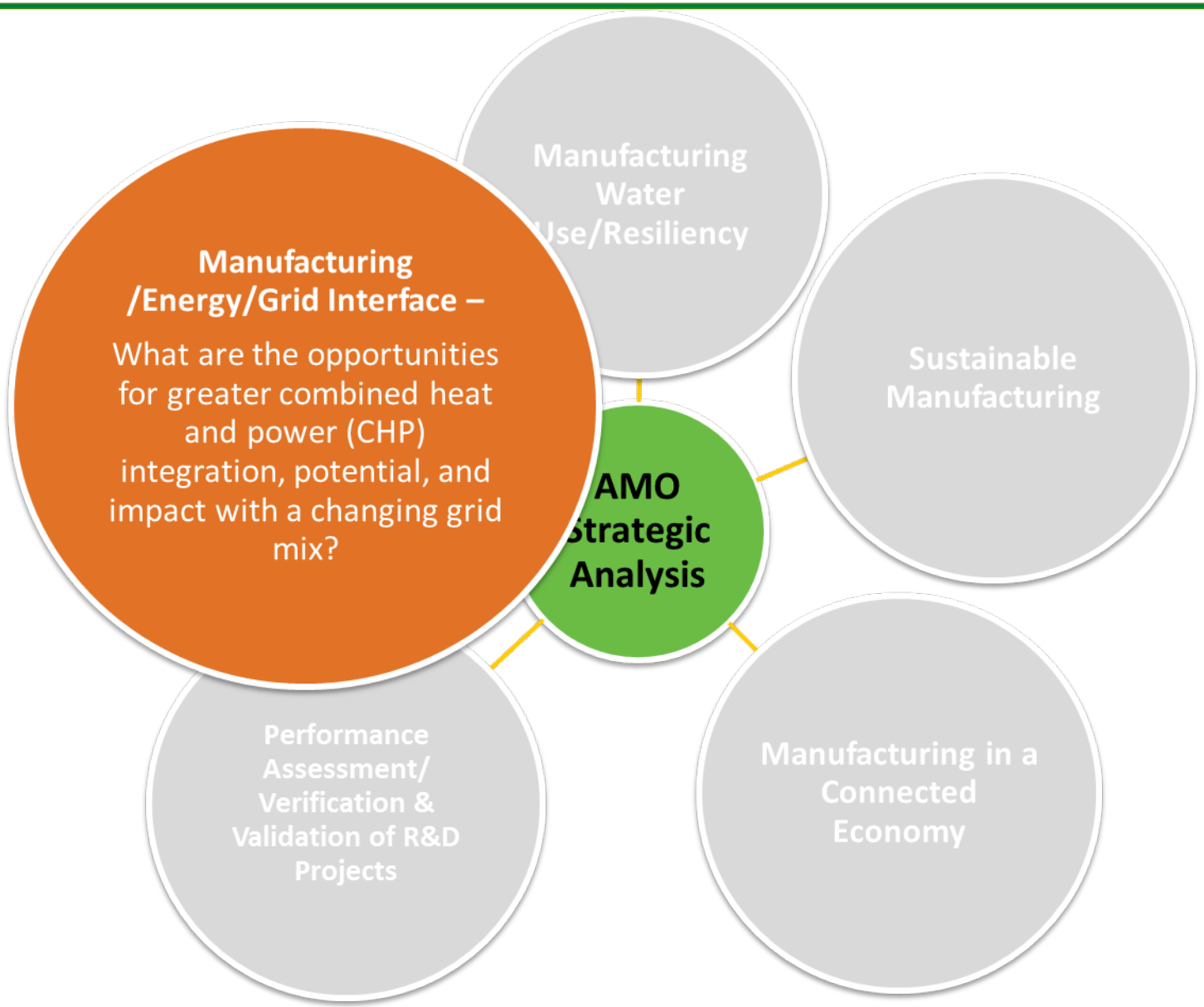
AMO Analysis – Current Focus Areas

Credible data and information to inform current and future AMO priorities



Poster Session

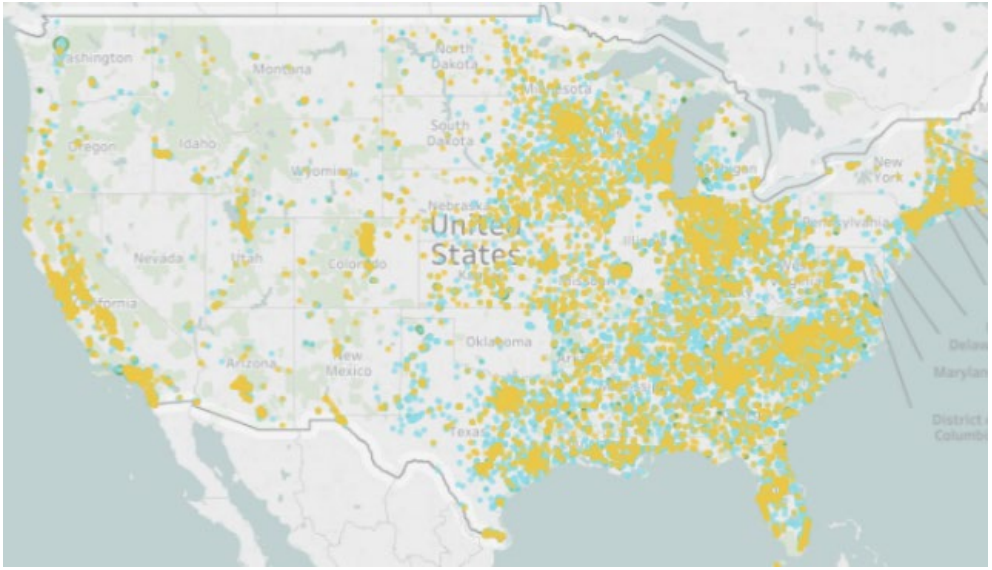
AMO Analysis Focus Areas



Combined Heat and Power (CHP)/Smart Power Electronics Analysis

CHP and its greater integration, potential, and impact at manufacturing plant level:

1. Geospatial CHP Potential Analysis Using the Industrial Geospatial Analysis Tool for Energy Evaluations (IGATE-E) CHP Tool
2. Modeling the Impact of Advanced CHP on the Future Electric Grid
3. Power Electronics Potential for Grid Integration



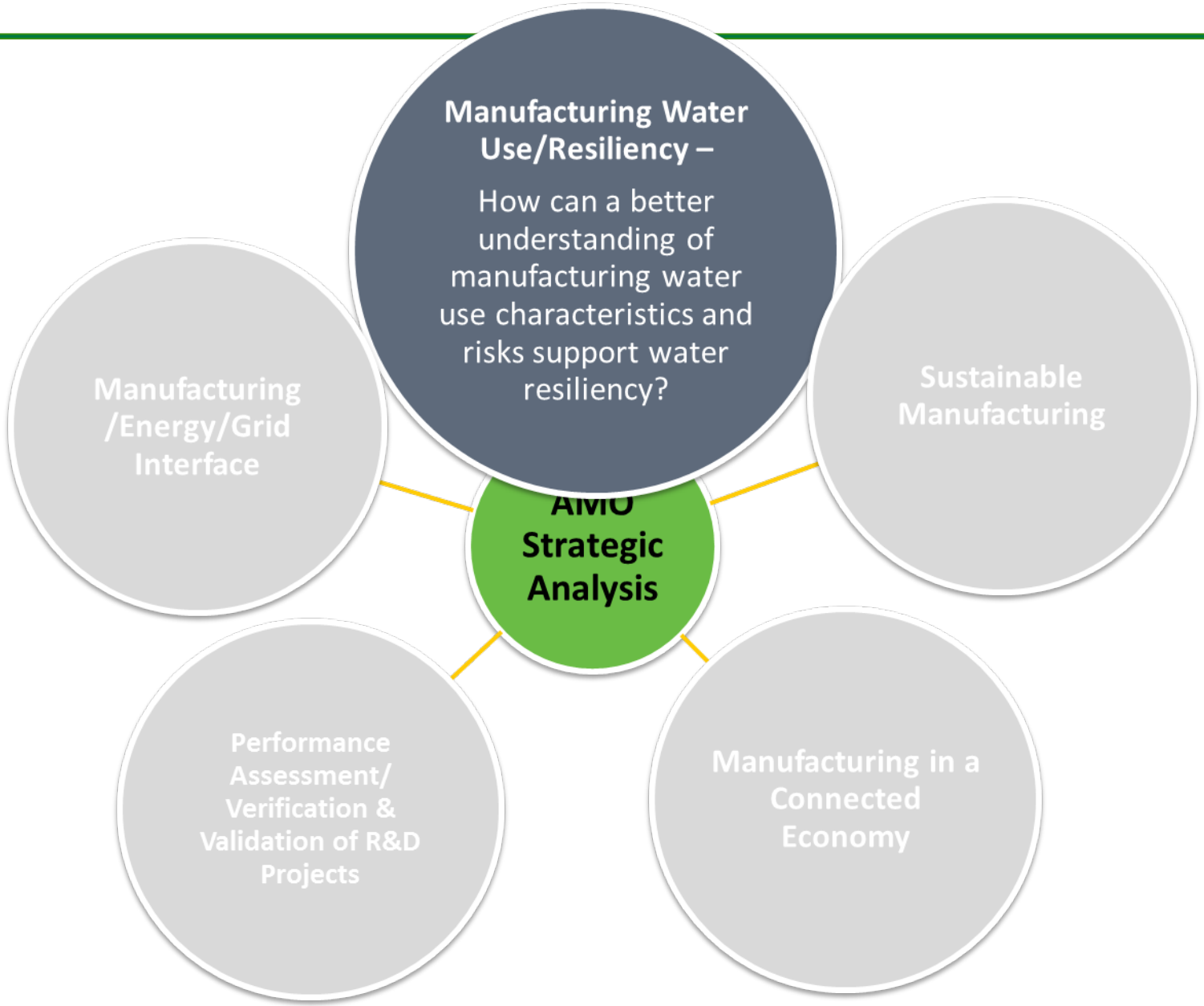
Power Electronics Grid Integration Potential

- Analysis of smart grid interconnection technology for industrial CHP facilities
- Examine cost, integration requirements, equipment, manufacturers, distributed energy resources (DERs) suppliers, and barriers

IGATE-E CHP Analysis

- Evaluate CHP feasibility at plant level & forecast CHP penetration potential
- Estimated CHP potential U.S. wide (above)
- CA studied in detail, modeling of traditional and advanced CHP deployment
- Expansion to commercial, & institutional buildings

AMO Analysis Focus Areas



Water Risk & Resilience in Manufacturing

Problem : Water is an essential resource, but low priority for most U.S. manufacturers

- **Water risks can compromise** a competitive manufacturing sector (due to expected water shortages, increased water stress)

Water Resiliency & Risk

- **Manufacturing water resiliency**: mitigating and recovering from production impacts associated with realizing physical, regulatory, societal, and/or economic risks associated with use of a shared watershed

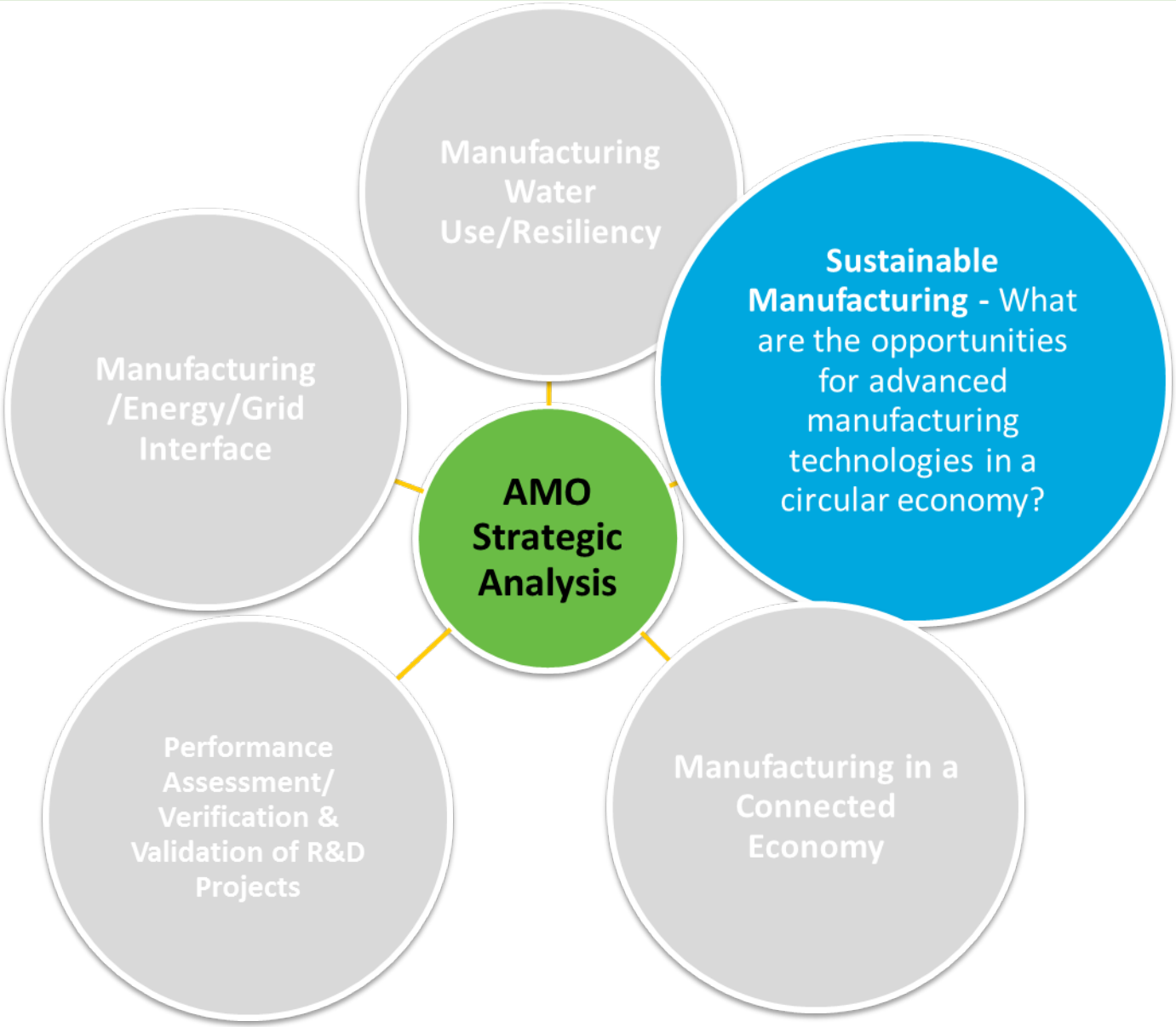
Current analysis goals:

- Manufacturing water use characteristics
- Water-related risks facing manufacturers
- Water conservation to support resilience

Focus areas:

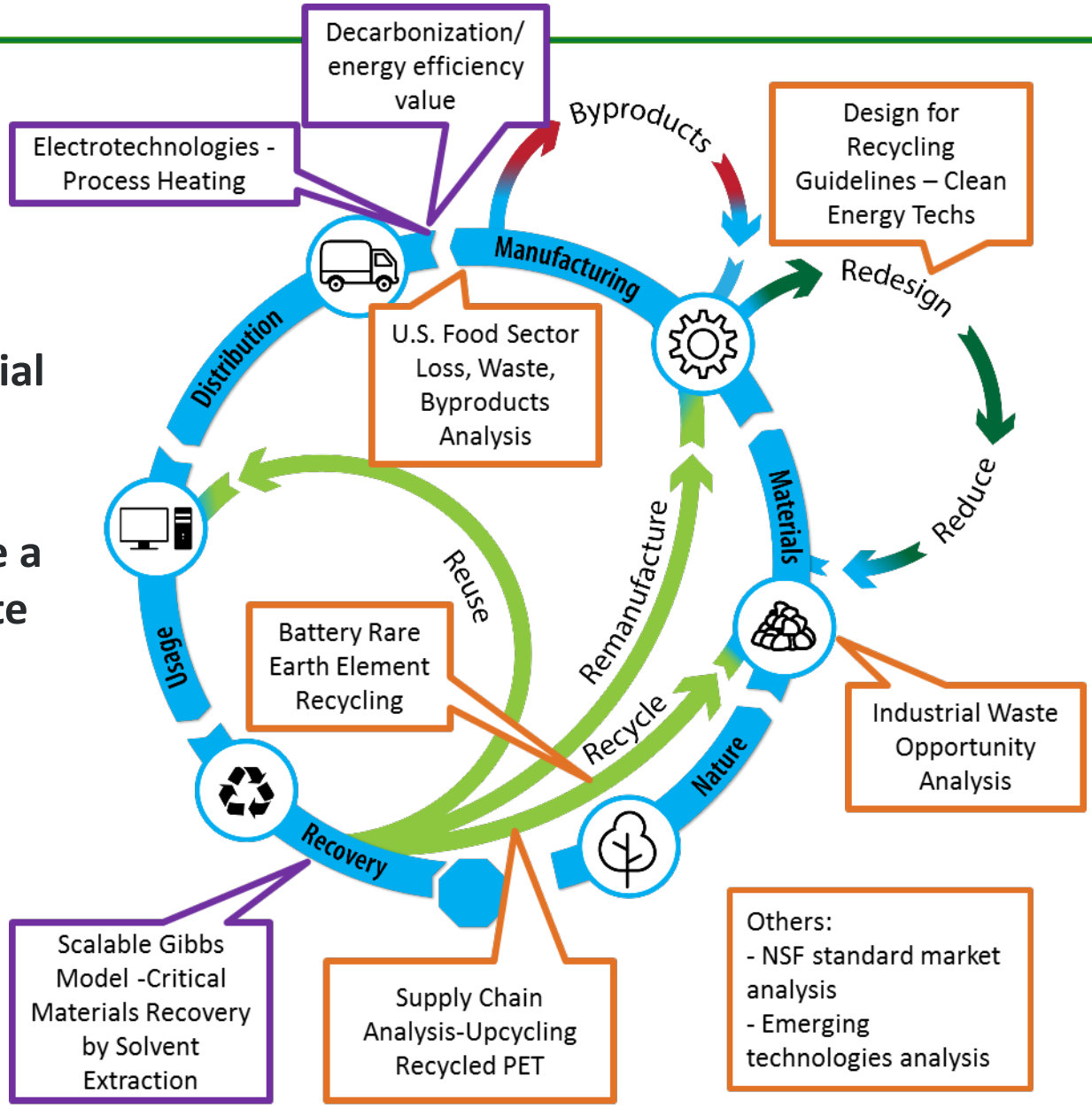
1. Mfg. water use characteristic data
2. Sub-facility level understanding of water use
3. Incorporate water use risk into analysis
4. Opportunities for industrial water reuse
5. Industrial wastewater treatment as an ancillary service
6. Dry factories

AMO Analysis Focus Areas

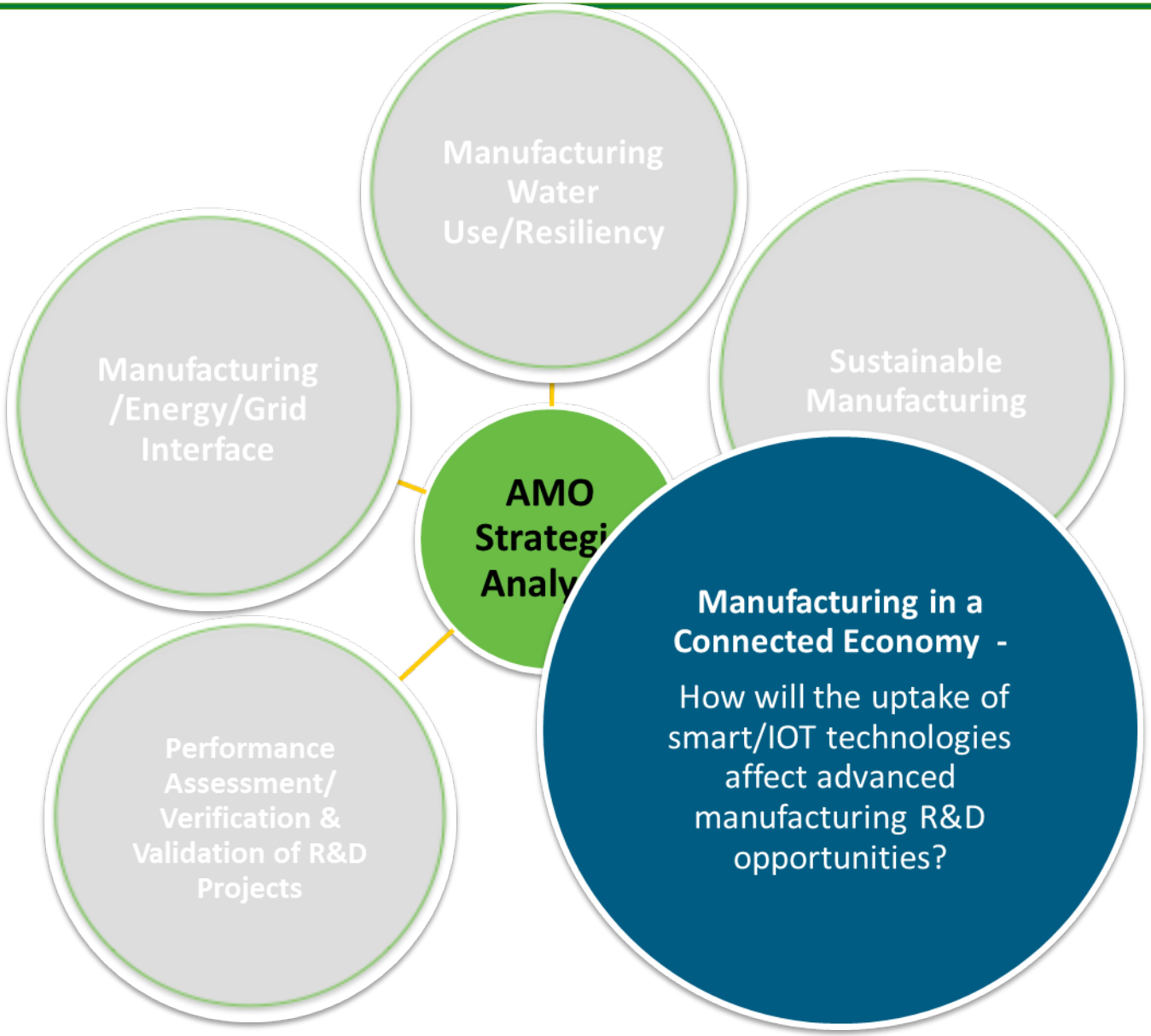


Sustainable Manufacturing → transitioning to a circular economy

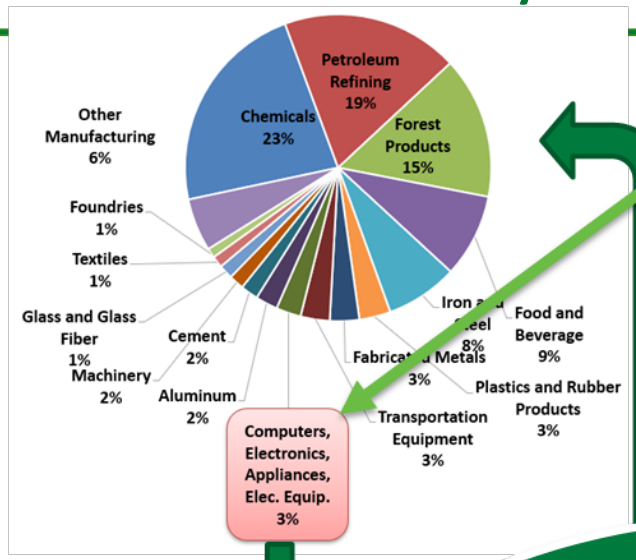
- **Reduce energy and material use in the manufacturing sector**
- **Establish a baseline to use a reference point to evaluate different Re-X strategies**



Mfg. in a Connected Economy



How does ICT impact the productivity and energy footprint of the entire Connected Economy?



Upstream Electronics Manufacturing Impacts

- Demand for electronics with ICT growth?
- U.S. supply chain vulnerabilities?
- Regional variation in production practices, material availability
- Life-cycle energy/waste impacts

Smart Manufacturing

- Opportunities to apply smart manufacturing technologies
- ICT requirements for transitioning to smaller factories
- Sector-specific benefits and bottlenecks

ICT Applications

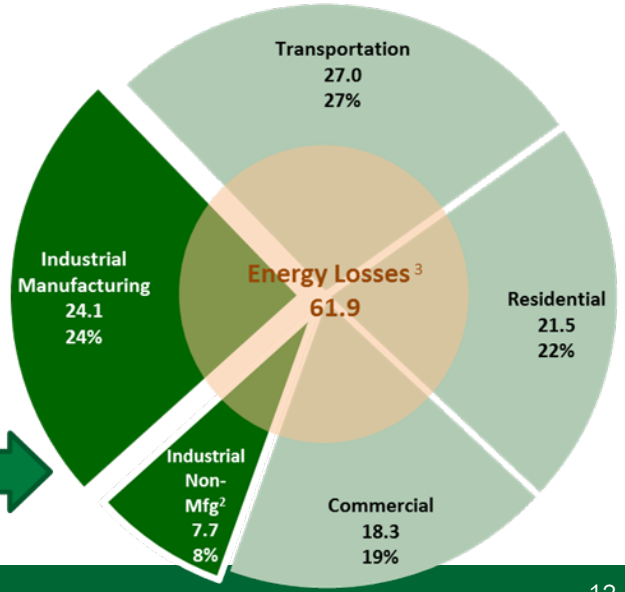
- Information/data generation
- Data collection/ storage/ retrieval
- Data control/ learning/ analysis
- Data transformation & visualization

Information and Communication Technology (ICT)

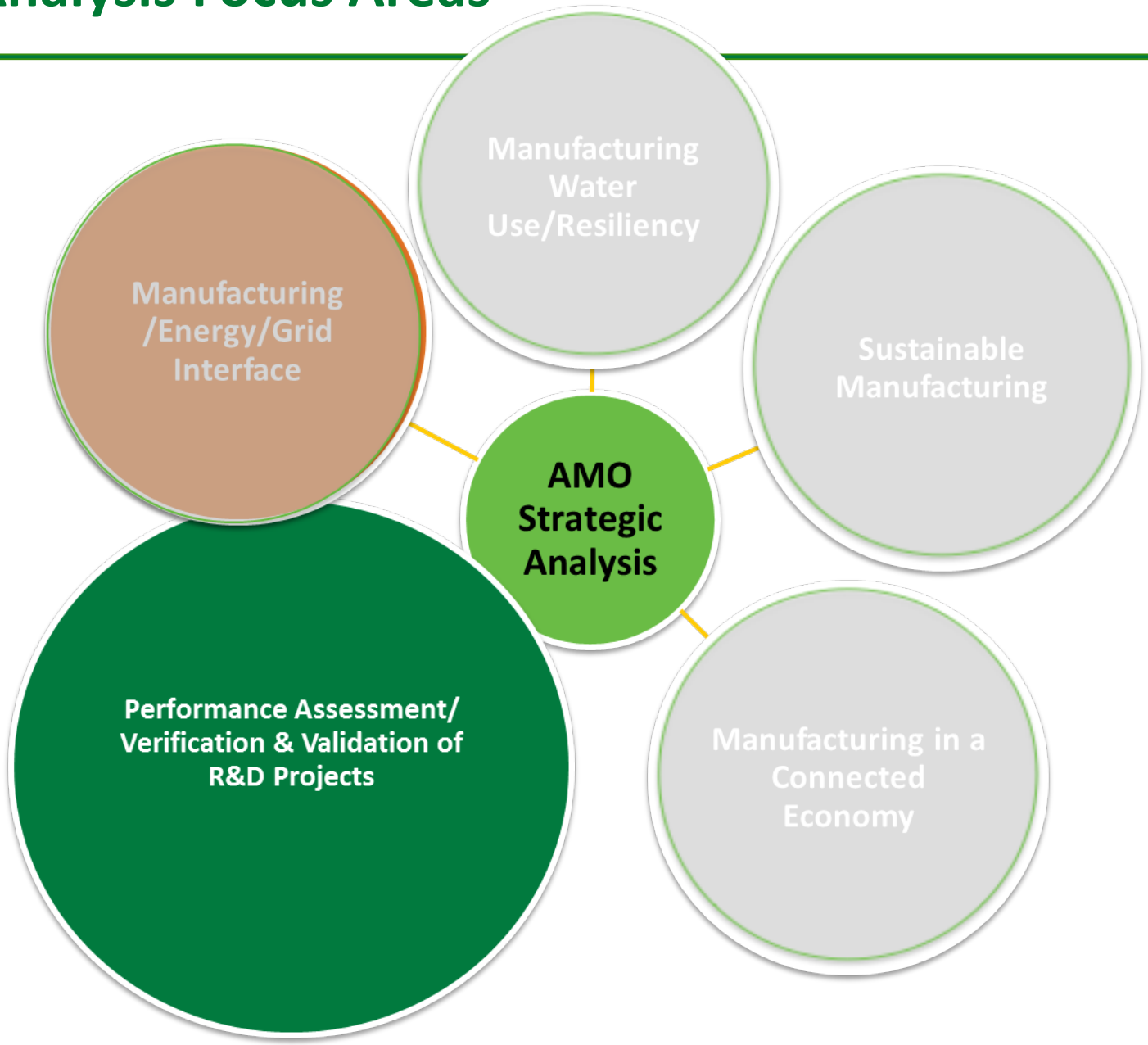
- Data Centers
- Data Networks
- Connected Devices

ICT Infrastructure Analysis:

- Resource demands of developing & operating an advanced secure, & reliable ICT infrastructure
- How demands will change with more connected devices



AMO Analysis Focus Areas



Develop an Introspective Performance Assessment with Verification and Validation (IPA/V&V) of R&D Projects Method for AMO

Addresses AMO 2018 Peer Review Panel Recommendations

- ... expand the use of techno-economic assessment ... in proposal selection and initial project implementation, particularly for early-stage research efforts.
- ... expand collaboration among AMO Technology Managers to identify best practices ... and disseminate to other projects or activities that may benefit from those best practices.

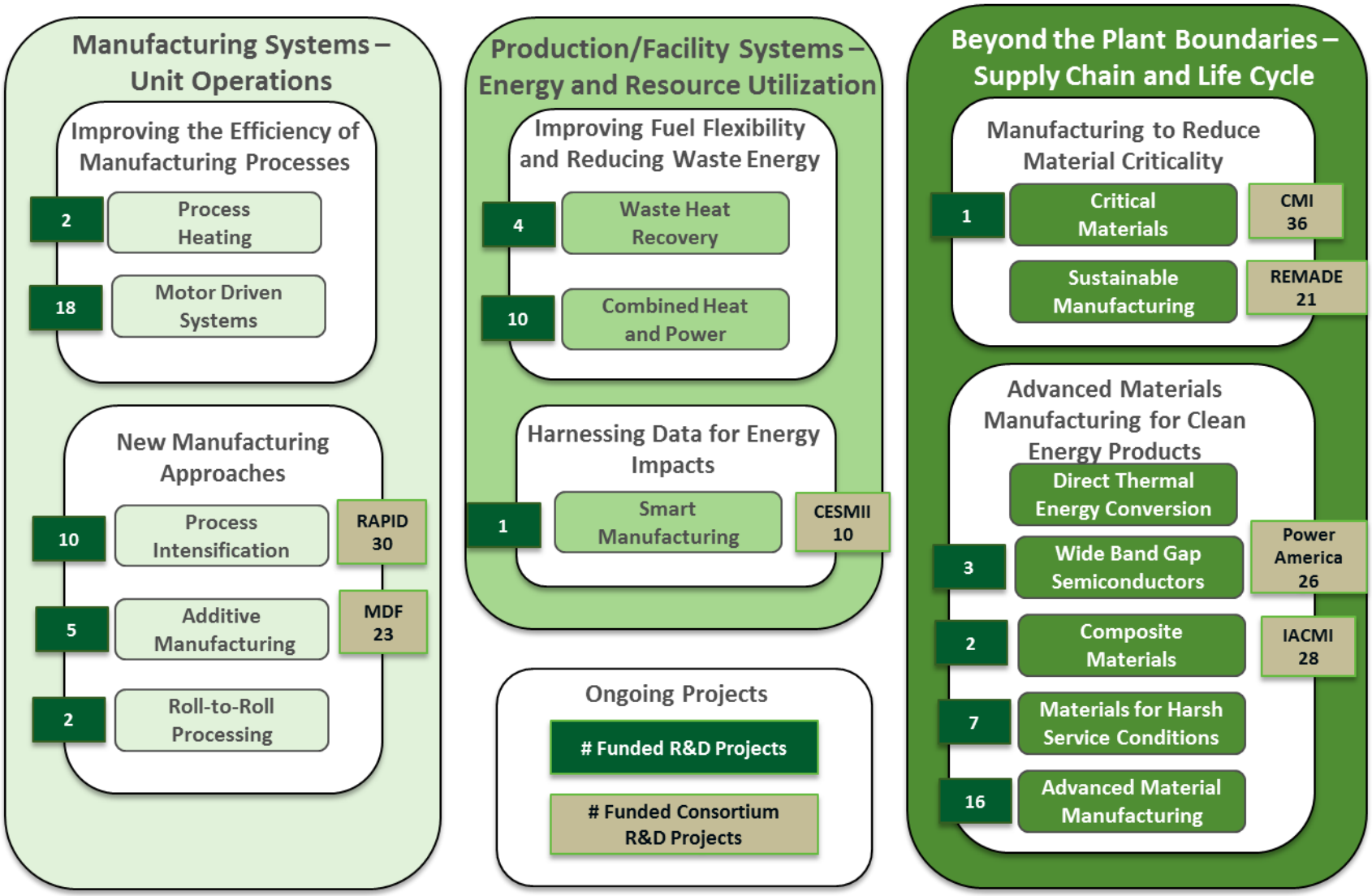
Goal: Establish formal process to assess & communicate the progress and contribution of currently funded projects to:

→ AMO's foundational technology areas

→Strategic goals

→ Success indicators

Challenge: AMO has a diverse portfolio of funded projects

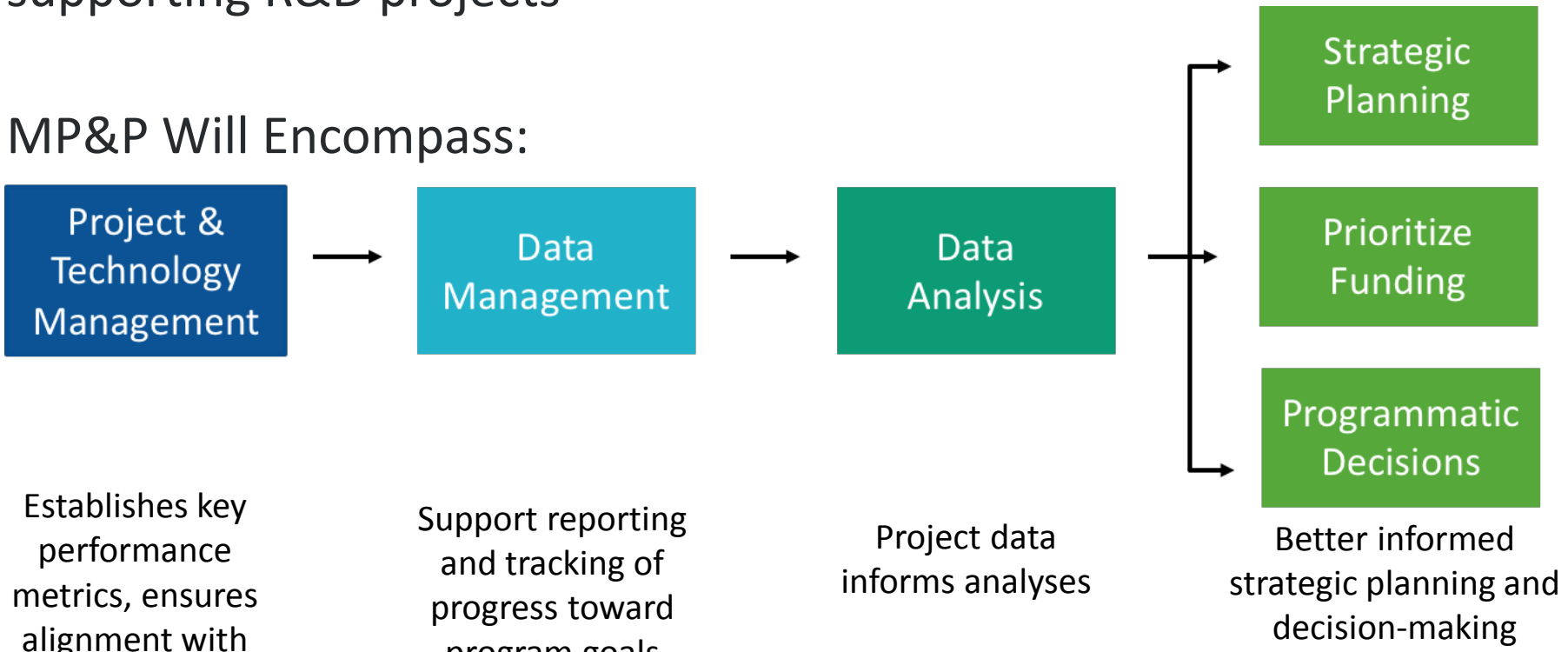


AMO Multi-year Program Plan (MYPP) lays out targets for fourteen core AMO manufacturing technology areas, organized around three manufacturing system levels.

AMO IPA/V&V Objective

- Develop and codify a **methodology, process and procedures (MP&P)** to provide AMO a consistent, transparent and defensible accounting of anticipated benefits of currently funded technologies and supporting R&D projects

- MP&P Will Encompass:



Metrics

Verify and report progress in terms of:

Cost

- Develop **techno-economic analyses to understand economic implications** of specific technologies and applications relative to the current state-of-the-art

AMO Energy Success Indicators

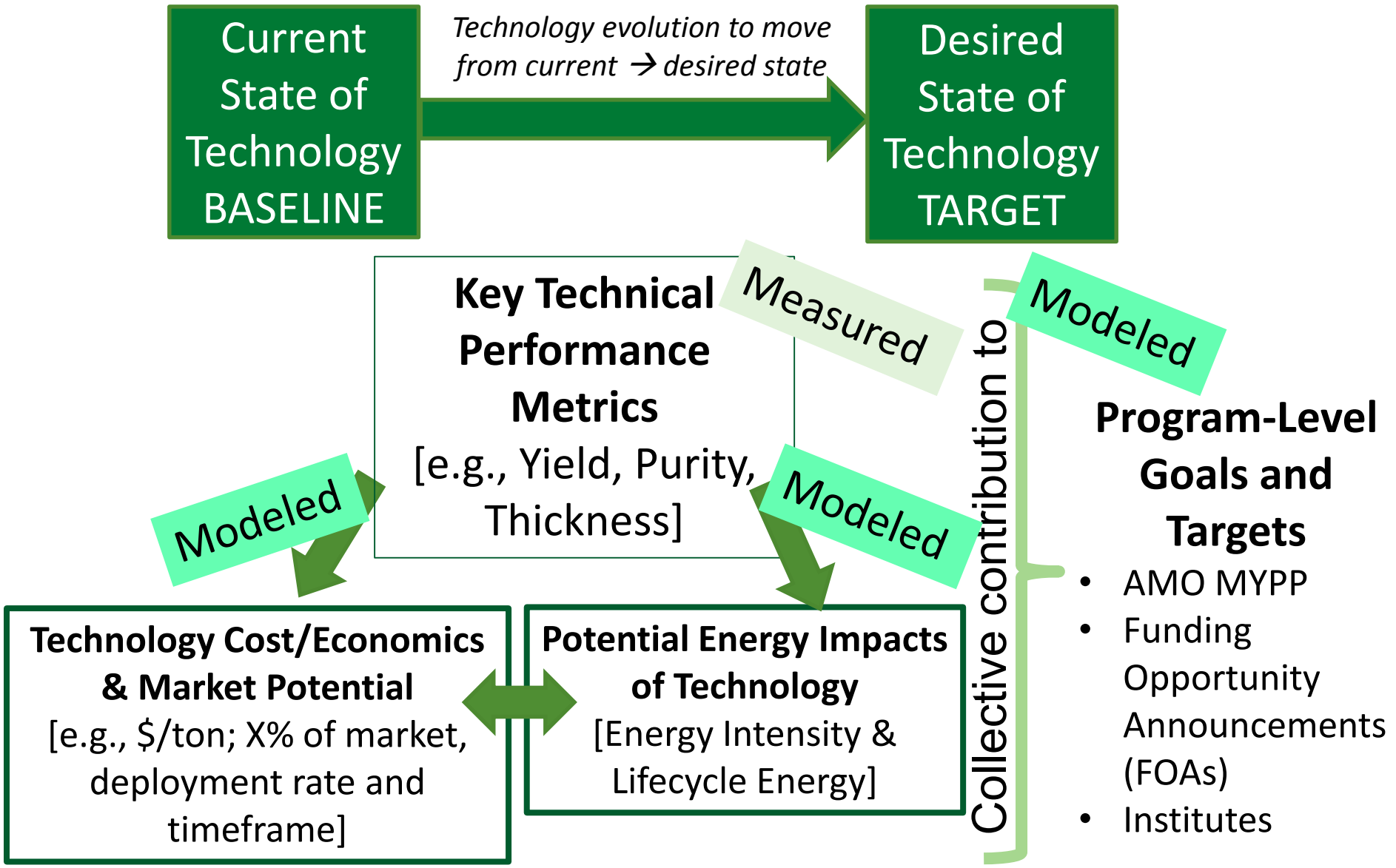
Energy Intensity

- Validate advanced materials, processes, and technologies that **reduce manufacturing energy intensity** by 20% by 2023 compared to the 2015 average technology.

Lifecycle Energy

- Advance materials and manufacturing technologies with the potential to **reduce life cycle energy** by 50% by 2023 compared to the 2015 state-of-the-art.

AMO IPA/V&V Goals and Data Needs



Development of an Introspective Performance Assessment with Verification and Validation (IPA/V&V) of R&D Projects Method for AMO

Multi-year Effort

- Three-year development plan with staged approach to establish and implement a methodology, process and procedures (MP&P)
- Consistently set and assess technical, economic, and energy performance metrics for technologies and supporting R&D projects

Establish Two-Tier Framework

- **Tier 1** – Collect and report basic performance metrics for all AMO-funded R&D projects, using existing Active Project Management practices where possible
- **Tier 2** – Given large number of R&D projects, select representative cross-section for more rigorous V&V assessment procedure

Leverage Existing MP&P

- Evaluate (and modify/integrate to meet AMO IPA/V&V requirements) current and past EERE/AMO methodologies and tools used to assess and track program and project performance

Pilot & Implement

- **Pilot** Tier 2 MP&P on select FY19 projects, revise based on pilot results, then expand to additional projects in broader FY20/FY21 AMO portfolio
- **Train** stakeholders (technology managers, principal investigators, analysts, subcontractors, etc.)

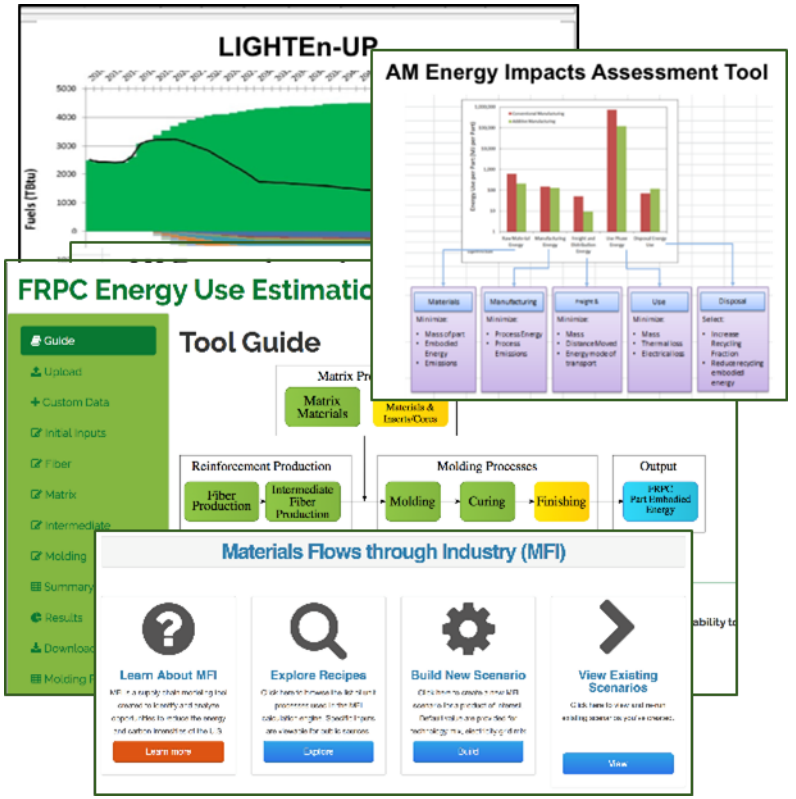
AMO IPA/V&V FY19 Tier 2 Pilot Focus

- **Approach:** Include multiple technology areas and project types (i.e., direct R&D and Institute-funded) to ensure flexibility of methodology, process and procedures (MP&P)

- Select FY19 funded projects:
  - Institute for Advanced Composites Manufacturing Innovation (IACMI)
  - Rapid Advancement in Process Intensification Deployment (RAPID) Institute
  - Process Intensification R&D projects
- New areas in process of scoping:
  - Clean Energy Smart Manufacturing Innovation Institute (CESMII)
  - Cybersecurity Institute for Energy Efficient Manufacturing

Existing AMO Tools/Models to Support AMO IPA/V&V

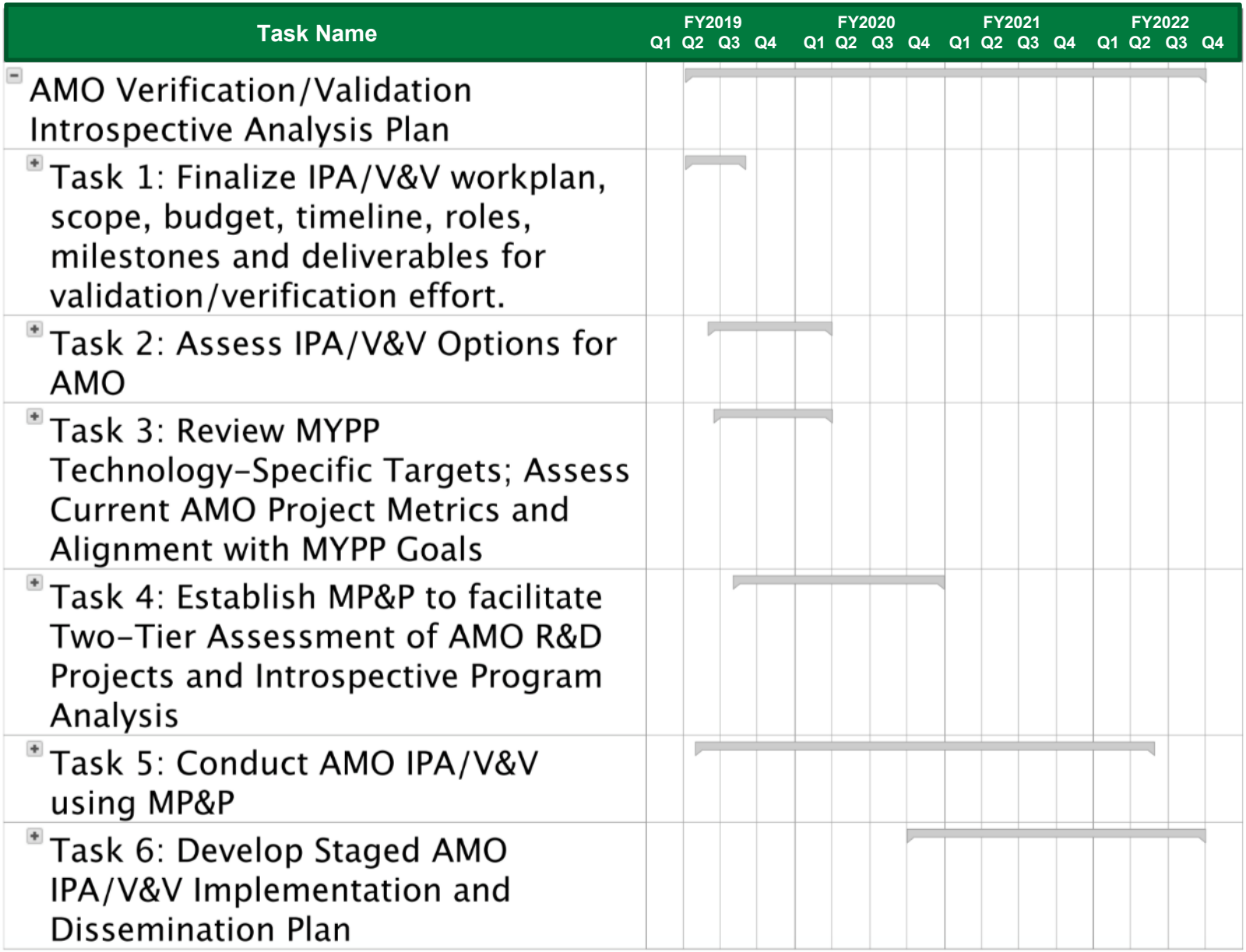
- **Cross-cutting Energy Assessment Tools/Models**
  - Life Cycle GHG, Technology and Energy through the Use Phase (LIGHTEn-UP) Tool (LBNL)
  - Material Flows Through Industry (MFI) – Supply Chain Focus (NREL)
- **Technology-Targeted Assessment Tools/Models**
  - Carbon Fiber Reinforced Plastic (CFRP) Energy Estimator Tool (ORNL)
  - Additive Manufacturing Energy Impacts Assessment Tool (ORNL)
- **Technology Cost Assessment Tools/Models**
  - Wind turbine blade manufacturing cost model (NREL/ORNL)
  - Auto components (e.g., floor pan, door inner, hood inner) cost model (ORNL)
  - Wide Bandgap (WBG) for motor drives manufacturing cost model (NREL)
- **Outside-AMO Tools/Models**



Additional data needs for projecting longer term impacts of R&D projects:

- *Market Potential (e.g., fraction of market impacted)*
- *Technology Maturation*
- *Technology Adoption Rate and Timing*

IPA/V&V Tasks and Tentative Timeline



AMO Strategic Analysis Team

Thank You

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For additional information:
energy.gov/eere/amo/advanced-manufacturing-office

ANL – Diane Graziano, Matt Riddle, John Murphy, Sarang Supekar, Nwike Iloeje

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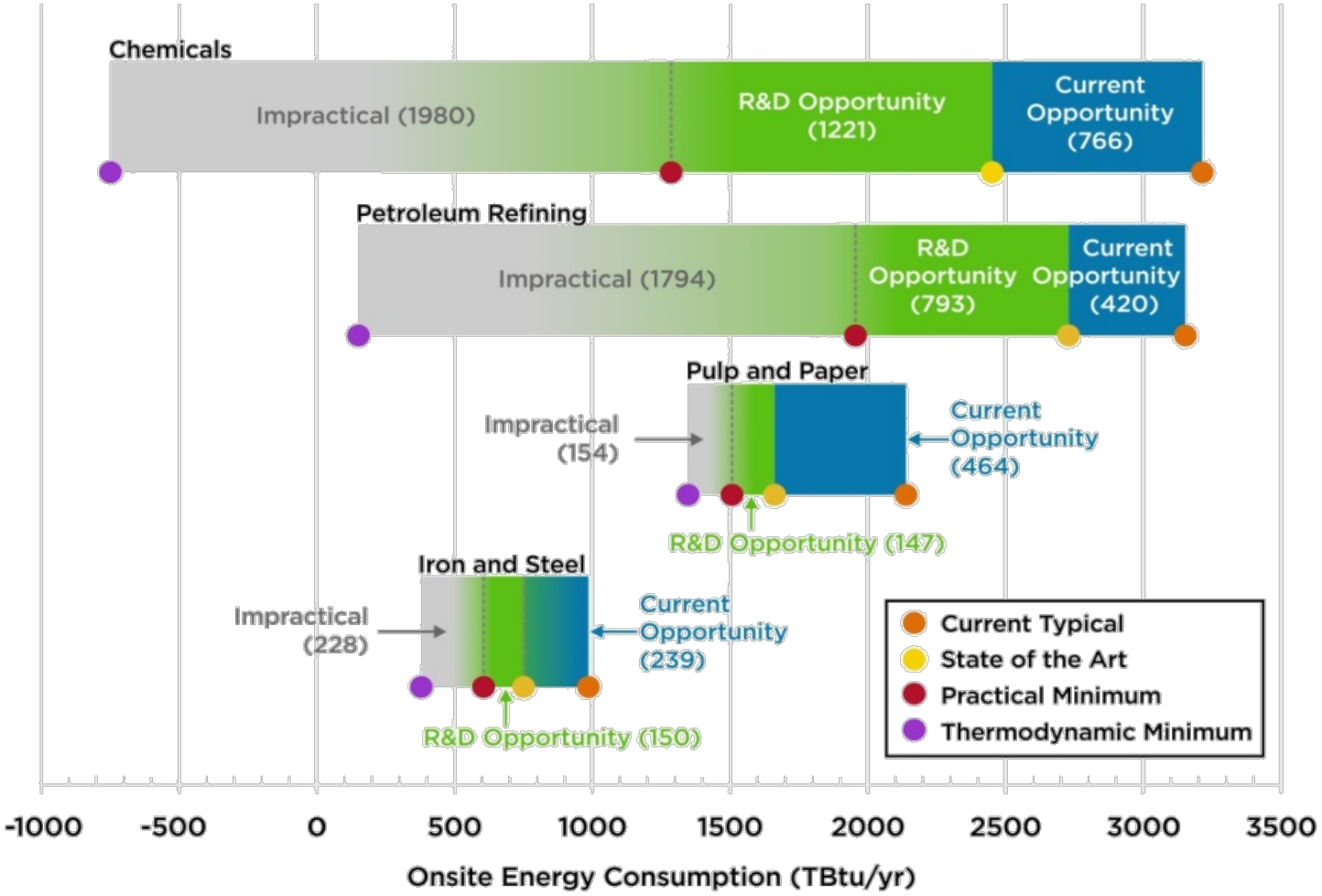
AMO Strategic Analysis Team - presentations, journal articles and technical reports (2013-Present)

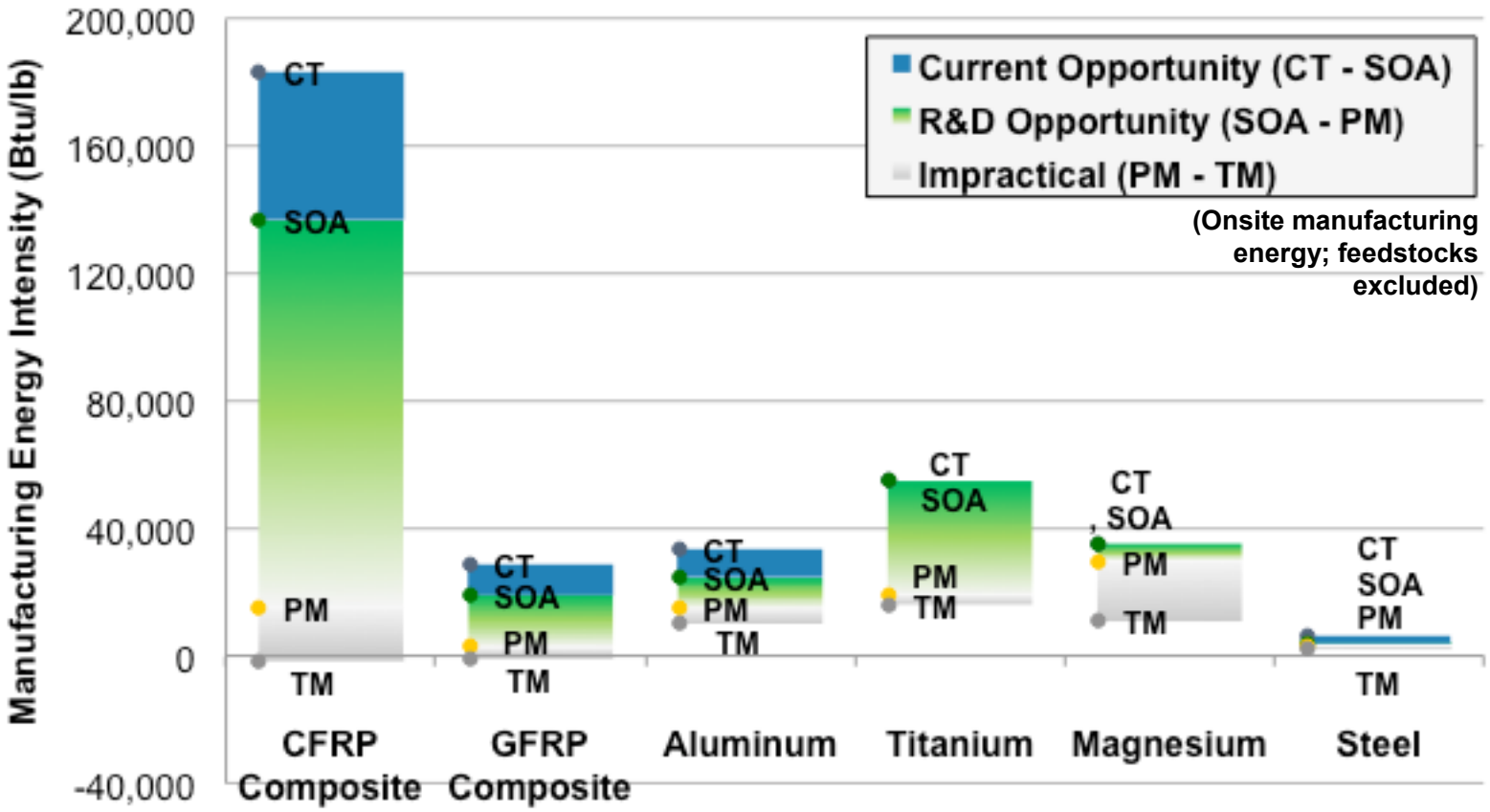
Manufacturing Bandwidth Studies

AMO: September 2015



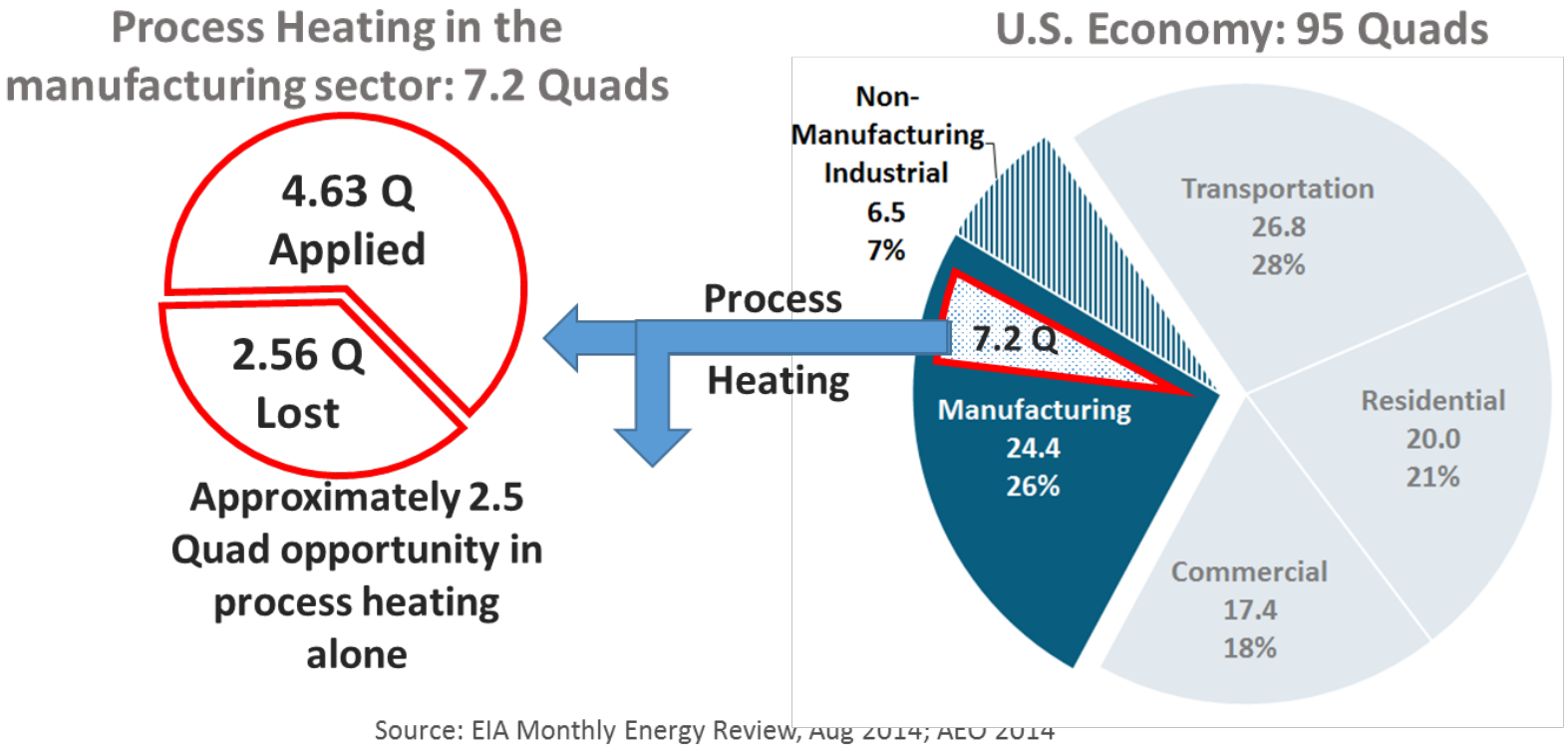
Current opportunities represent energy savings that could be achieved by deploying the most energy-efficient commercial technologies available worldwide. R&D opportunities represent potential savings that could be attained through successful deployment of applied R&D technologies under development worldwide. More info can be found at : https://www.energy.gov/eere/amo/energy-analysis-data-and-reports

Lightweight Materials



High manufacturing energy use drives costs up and reduces competitiveness with incumbent materials

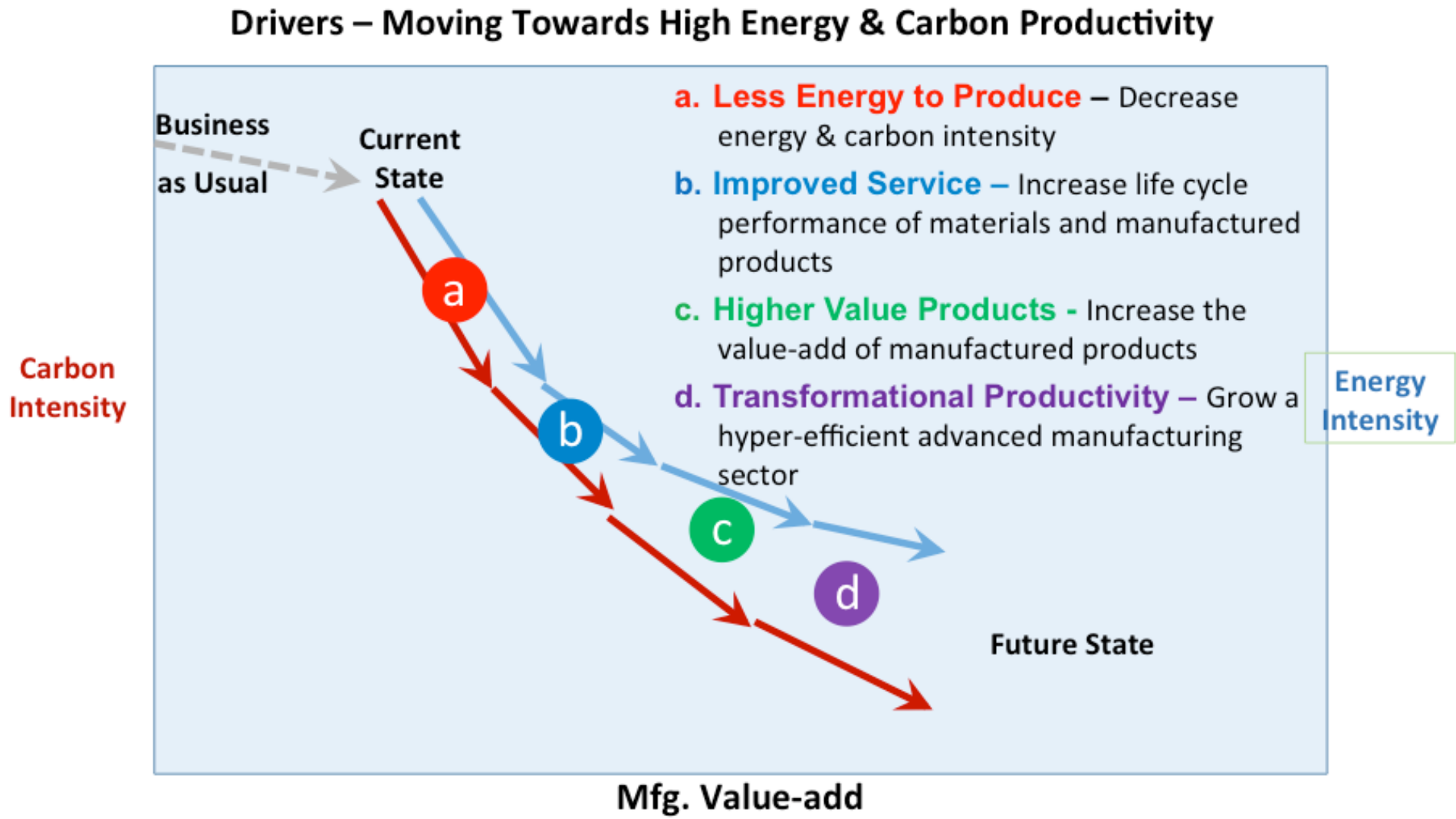
Cross-cutting opportunity



Source: EIA Monthly Energy Review, Aug 2014; AEO 2014

- **7 Quads**. Process heating accounts for a sizable fraction of total U.S. energy use, and more direct energy use than any other energy consuming processes in manufacturing.
- **95% fossil fuel based**. Traditional industrial (thermal) processes can be inefficient, difficult to control and result in materials and products with compromised quality and performance.

Drivers for Energy and Carbon Productivity



Energy Productivity Drivers

a. **Less Energy to Produce –** Decrease energy intensity (i.e. **energy/mass**) of existing commodities/materials by developing new pathways towards practically achievable minimum energy requirements.

b. **Improved Service –** Increase life cycle performance of materials and manufactured products (i.e. **service/mass**) via approaches such as hyper-utilizing existing commodities and materials that result in significantly greater service for the amount of material used.

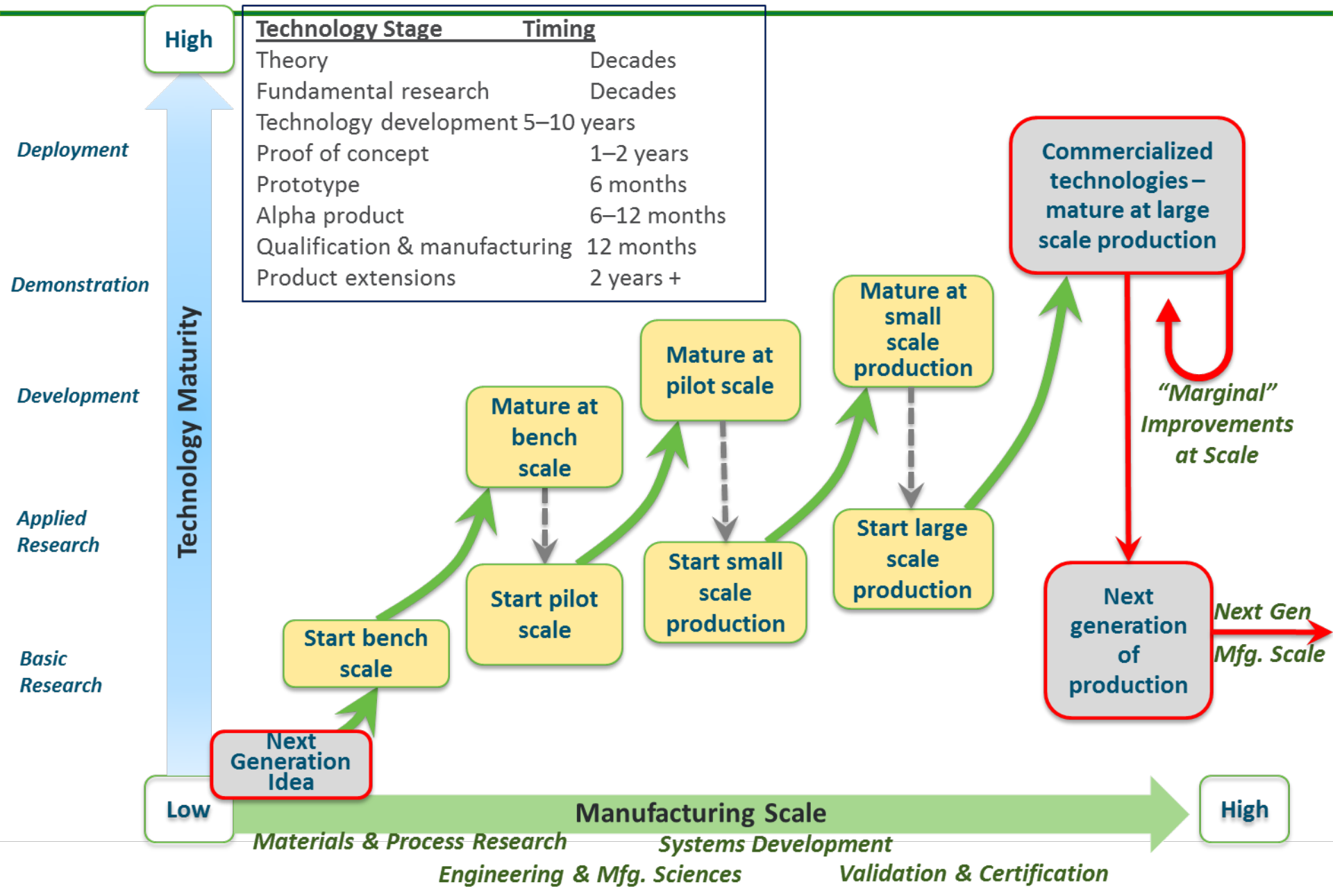
c. **Higher Value Products -** Increase the value-add of manufactured products (**i.e. value-add/service**) by developing new, high-value commodities and materials substitutes that can be manufactured at scale with energy and emissions that are lower than the practical limits of existing commodities and materials

d. **Transformational Productivity –** Grow a hyper-efficient advanced manufacturing sector

- with a particular focus on new greenfield development of low energy, low-carbon high value-add materials and products;
- target those technologies and processes that can exceed current practical limits of energy and carbon productivity; and
- anticipate and develop technologies that optimize life cycle resource efficiency to prevent the possible future rebound of energy & carbon intensive production.

Innovation is not linear

Opportunities to accelerate innovation

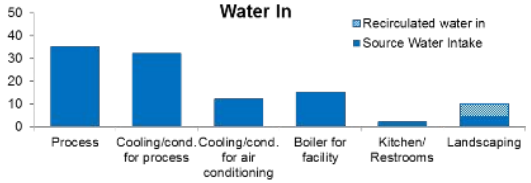


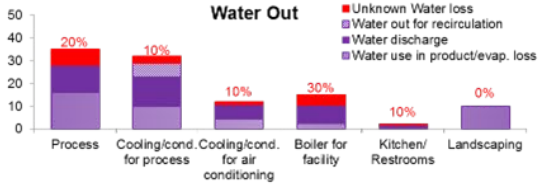
Manufacturing Water Conservation Analysis Underway: Plant Water Profiler tool

Plant Water Profiler

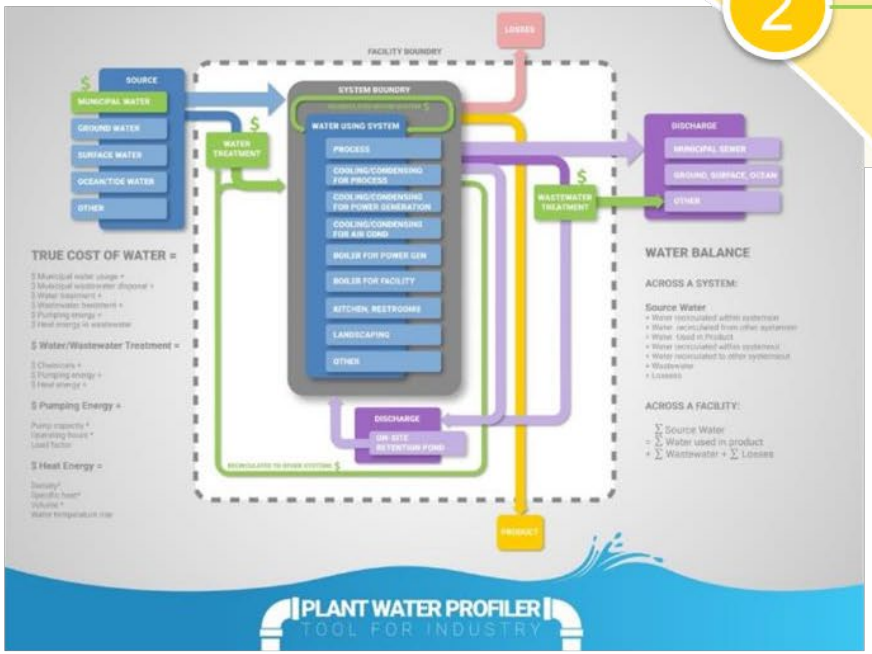
OAK RIDGE National Laboratory

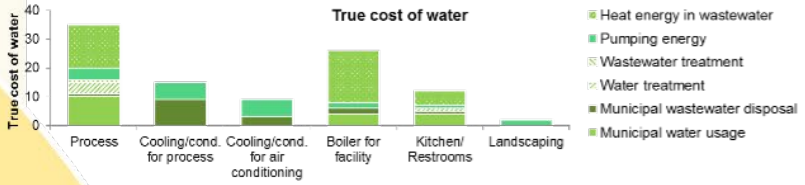
1 Baseline Water Use and Water Balance



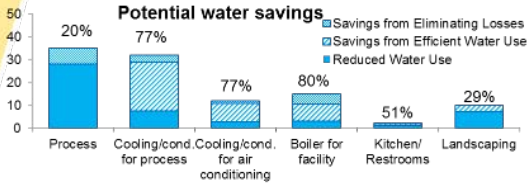


2 Determine True Cost of Water





3 Identify Water Efficiency Opportunities



Applying manufacturing water use analysis

Objective:
Help to harden U.S. manufacturing against current and future water issues using analysis

Challenges:
- Risk greater driver than economics
- Risks highly spatially and temporally dependent
- Lack of data and information

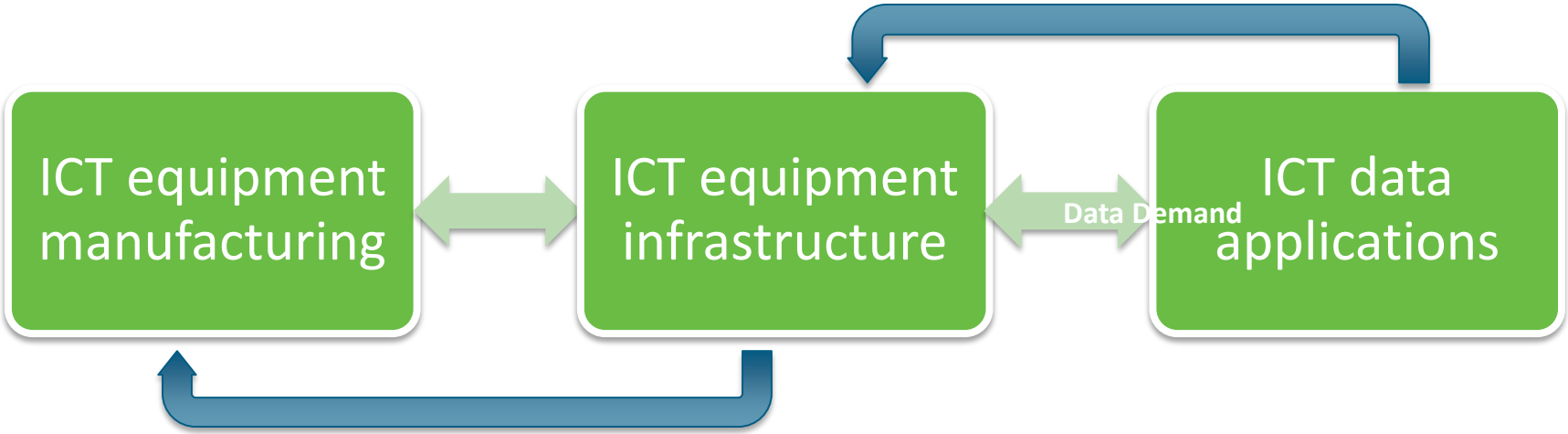
AMO StA approach:
- Characterize manufacturing water use
- Quantify risks and evaluate implications on U.S. manufacturing
- Evaluate technologies responsive to risks

AMO:
Develop new or support existing energy-water initiatives

Broader Community:
Include manufacturing sector in water initiatives

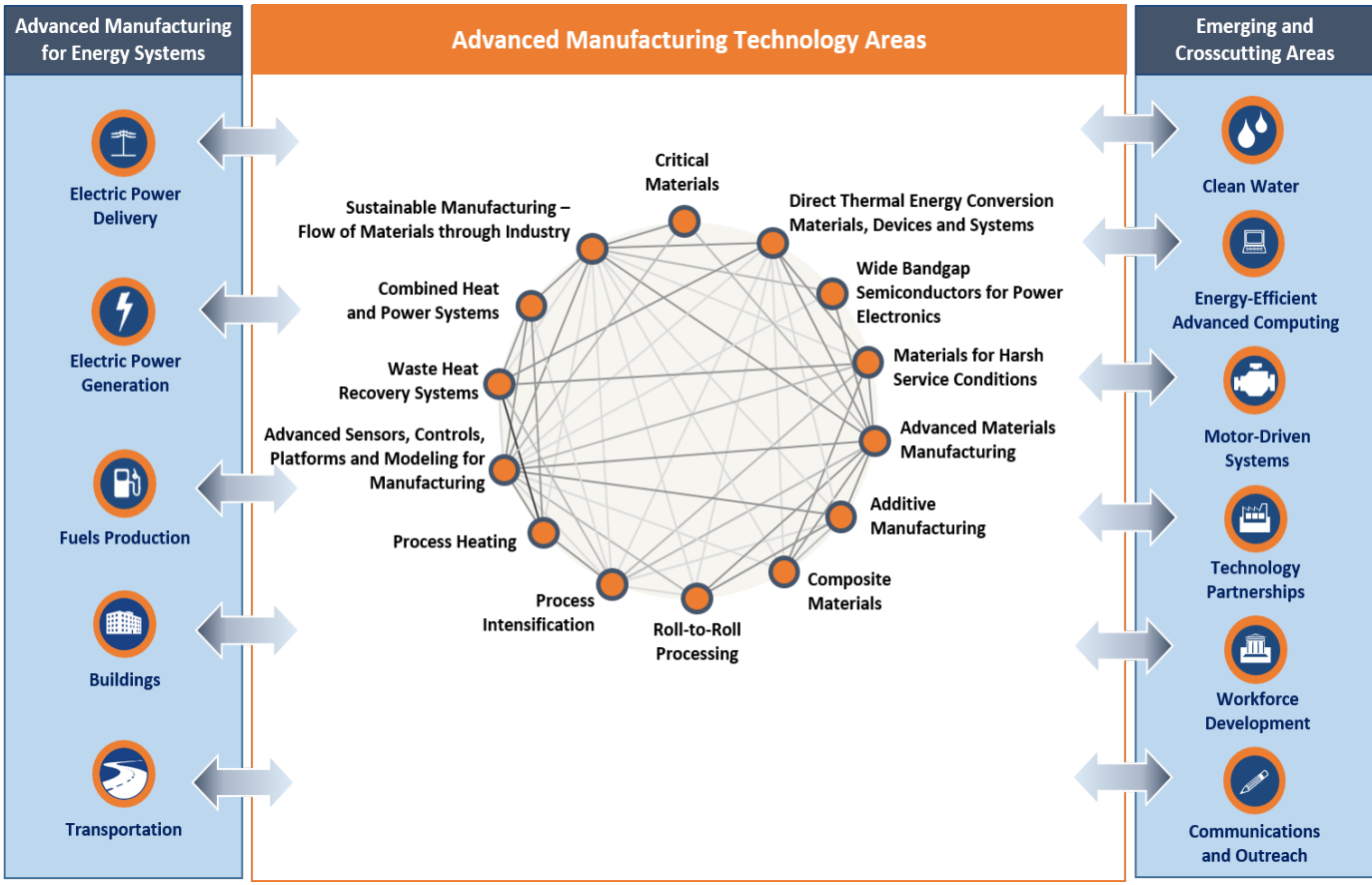
Connected Economy Analysis Overview

- **Impacts of Information and communication technology (ICT):**
  - Creating a connected economy (CE) with data collected, transported, stored, and processed into actionable knowledge when & where needed
  - Reshape manufacturing practices to increase productivity & leveraged to make products with a competitive advantage
- **Benefits:** Failing to utilize advanced, secure, and reliable ICT infrastructure could lead to competitive vulnerabilities in the U.S. manufacturing sector



Development of an Introspective Performance Assessment with Verification and Validation (IPA/V&V) of R&D Projects Method for AMO

- **AMO portfolio:** broadly covers interconnected advanced manufacturing technology areas with potential to significantly improve manufacturing energy efficiency and minimize the life-cycle energy of manufactured products
- **AMO Multi-Year Program Plan (MYPP):** lays out technology-specific performance, economic and energy metrics for each technology area



IPA/V&V General Concept for Data Metrics and Reporting

Project/Technology Information/Overview				
Project/Technology Title	Description	Focus Area	Partners	Drivers of Cost/Energy Improvement
Application(s)/End Use(s)	TRL/MRL	Barriers	Market Potential	Technology Maturation/Uptake Plan

Project/Technology Metrics					MYPP Link
	Project/Technology			Commercial Potential	
	Baseline State of Technology (SOT), Date	Interim Target, Date	Final Target, Date	Target, date	
Design/Model Assumptions and Technical Performance					
Technology/Process					
Scale					
Key Technical Metric 1					X
Key Technical Metric etc.					X
Economics					
Cost Metric Calculation	Model/Tool/Key Assumptions Documentation/Link				
Capital Cost					
Operating Cost					
Unit Cost (e.g. $/kg)					X
Energy					
Energy Metric Calculations	Models/Tools/Key Assumptions Documentation/Link (EI and LC Energy)				
Energy Intensity (e.g. J/kg)					X
Lifecycle Energy Impact					X

2019

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